Abstract

This thesis presents the prospects for detecting neutral and charged long-lived particles (LLPs) with the International Large Detector (ILD) assuming its operation at the future e^+e^- International Linear Collider (ILC) with $\sqrt{s} = 250\,\text{GeV}$. The main tracker of the ILD is a large time projection chamber (TPC), which allows for almost continuous tracking. The study was performed using full `Geant4` simulation for a set of benchmark scenarios. Multiple background sources were taken into account, both from low-p_T beam-induced processes, as well as Standard Model interactions with high-p_T final states. The analysis incorporated an experiment-orientated approach, in which instead of studying particular points in the parameter space of a specific model, benchmarks were selected based on the experimental signature and kinematic properties of the final state, allowing to test the detector capabilities and reconstruction tools. The study was therefore carried out in a model-independent way, and the results are presented as a function of physical parameters, such as LLP decay lengths or masses.

For neutral LLPs, two classes of benchmarks were selected. The first one involved a little boosted, low-p_T final state, resulting from a small mass difference between a heavy LLP and a dark matter particle created in the LLP decay. The second introduced a very light LLP which, due to its large boost, produced high-p_T, strongly collimated final-state tracks. The signature of a displaced vertex was considered, and the analysis relied on a vertex-finding procedure designed for this work. It was also extended to a study of exotic Higgs decays, where the model-independent approach was tested, and the search was optimised for this specific BSM scenario.

For charged LLPs, the analysis was designed based on the experience of the search for neutral LLPs. The benchmarks involved pair-production of charged LLPs which could decay into a lepton and a dark matter particle, resulting in the signature of a kinked track. Two LLP masses (high and moderate) were considered, with a set of mass differences between LLP and dark matter selected for each of them. The search was performed using a kinked-track finding tool that was optimised for this study.

The results indicate that LLPs can be detected with the ILD for a wide range of lifetimes thanks to the large acceptance of the TPC. The study has shown that for the ILC running at 250 GeV signal production cross sections at the level of 0.1 fb can be probed for most of the scenarios considered, and the Higgs boson branching ratios to LLPs down to 10^{-4} can be reached. This demonstrates the potential of the ILD experiment in detecting the LLPs.